River Valley High School 2024 JC 2 H1 Chemistry 8873 Prelim Exam Paper 2 Suggested Solution

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2		$\begin{array}{ c c c c c c c c c c c c c c c c c c c$	
Ζ		$\circ \circ \circ \circ$	
	( H )	( )	

(b) Shape: <u>Trigonal pyramidal</u> Bond angle: <u>107°</u>

Explanation: There are <u>3 bond pairs and one lone pair</u> of electrons around the central S atom. The electron pairs are arranged as far apart as possible to <u>minimise repulsion</u>.

- (c) Dative bond is formed when the <u>N atom donates a lone pair of electrons</u> into an <u>empty 1s orbital of an electron deficient H atom</u> for sharing. As a result, the electron deficient H atom achieves a stable duplet configuration.
- (d) <u>Ammonium sulfite has a higher boiling point</u> than ammonia.

<u>Ammonium sulfite has a giant ionic lattice structure</u> while <u>ammonia has a</u> <u>simple covalent structure</u>.

<u>More energy</u> is needed to overcome the <u>stronger electrostatic forces of</u> <u>attraction between  $NH_4^+$  and  $SO_3^{2-}$  ions</u> than the weaker <u>hydrogen bonding</u> <u>between  $NH_3$  molecules</u>.



**2** (a)  $Ca^{2+}(g) + 2Cl^{-}(g) \rightarrow CaCl_{2}(s)$ 

(b) Ionic radius of  $Ca^{2+} = 0.099 \text{ nm}$ Ionic radius of  $Mg^{2+} = 0.065 \text{ nm}$ 

$$|LE| \propto \left| \frac{q^+ q^-}{r^+ + r^-} \right|$$

<u>Magnitude of lattice energy of MgCl<sub>2</sub> is higher</u> as the <u>ionic radius of Mg<sup>2+</sup> is</u> <u>smaller than that of Ca<sup>2+</sup></u> (and both ions have the same charge), resulting in a (stronger electrostatic force of attraction between Mg<sup>2+</sup> and C*F* ions in MgC*l*<sub>2</sub>).

(c) [Ca(H<sub>2</sub>O)<sub>6</sub>]<sup>2+</sup> + H<sub>2</sub>O = [Ca(H<sub>2</sub>O)<sub>5</sub>(OH)]<sup>+</sup> + H<sub>3</sub>O<sup>+</sup>
 <u>Ca<sup>2+</sup> ions will polarise H<sub>2</sub>O molecule, causing partial hydrolysis to occur.</u> This will cause a small amount of H<sup>±</sup> to form, resulting in a solution of pH 6.5.

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(d) Amount of CaCO<sub>3</sub> =  $\frac{11.375}{100.1}$  = 0.1136 mol Amount of HCl =  $\frac{250}{1000}$  × 2.00 = 0.5000 mol Hence, CaCO<sub>3</sub> is limiting.

> Energy released = mc∆T = (250)(4.2)(1.58) = 1659 J = 1.659 kJ

 $x = -\frac{1.659}{0.1136}$ = -14.6 kJ mol<sup>-1</sup>

(e) (i) To prevent the solution from spraying out of the conical flask due to bubbling.

(ii) 
$$CaCO_3 \% CO_2$$
  
Mass loss = mass of CO<sub>2</sub> produced  
= 0.1136 × 44.0  
= 4.998 g  
= 5.00 g

(iii) Rate = k[HC*l*]



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An increase in temperature will lead to an <u>increase in the average</u> <u>kinetic energy</u> of reactant molecules. <u>More particles will have energy</u> <u>greater than or equal to  $E_a$ </u>.

The <u>frequency of effective collisions increases</u>. Hence, the rate of reaction increases.



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RV RV (a) Nanomaterial is a material with at least 1 dimension on nanoscale from 1 nm to 100 nm.

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- (b) <u>High tensile strength</u>. It has <u>strong covalent bonds between atoms</u> in a <u>giant</u> <u>network</u> of carbon atoms.
- (c) It is due to the (black) colour of CNT material which does not allow the driver to see through the window.

Or

CNT material is opaque.

(d) It has <u>delocalised valence electrons which act as mobile charge carriers</u> and will conduct static charges/conduct the accumulated charges away.

(e)	structures		
	names	Armchair	Zigzag

- 4 (a) Reaction 1: LiA*l*H<sub>4</sub> in dry ether Reject heat for LiA*l*H<sub>4</sub>
  - or H<sub>2</sub>, Ni, heat
  - or NaBH<sub>4</sub>
  - Reaction 2: Excess concentrated H<sub>2</sub>SO<sub>4</sub>, heat

Rejected Al<sub>2</sub>O<sub>3</sub> and heat because alcohol given is not a vapour



(c) CH<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>COOH







**5** (a) Polymers are macromolecules with at least 100 repeat units of monomers and average molar mass of at least 1000 g mol<sup>-1</sup>.

6

- (b) (i) Condensation polymerisation
  - (ii) Thermosetting polymer

There are strong covalent bonds as  $\underline{cross-linkages}$  between the chains.

(iii) Bakelite <u>cannot</u> be recycled.

A <u>large amount of energy is needed to overcome the strong covalent</u> <u>bond</u> cross linkages which will result in the thermal decomposition of Bakelite.



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# RVHS Chemistry

(c)

 $H \stackrel{\delta^{+}}{H} \xrightarrow{0} H$ 

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PVA dissolves in water by forming hydrogen bonds between its protonic hydrogen and the lone pair of electrons on the oxygen atom of water.

(a) Amount of S<sub>2</sub>O<sub>3</sub><sup>2-</sup> reacted =  $0.00150 \times \frac{25.60}{1000}$ =  $3.840 \times 10^{-5}$  mol  $4S_2O_3^{2-}\% 2I_2 \% 4Mn(OH)_3 \% O_2$ Amount of oxygen =  $\frac{1}{4} \times 3.840 \times 10^{-5}$ =  $9.60 \times 10^{-6}$  mol (b) (i) Half-equation: NO<sub>2</sub><sup>-</sup> + H<sub>2</sub>O + e<sup>-</sup>  $\rightarrow$  NO + 2OH<sup>-</sup>

Overall:  $2I^- + 2NO_2^- + 2H_2O \rightarrow I_2 + 2NO + 4OH^-$ 



(ii) Calculated DOC value is larger than the expected value.[√]
 Presence of NO<sub>2</sub><sup>-</sup> will cause more I<sub>2</sub> to form[√], which in turn causes a larger titre value of Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub>(aq) [√], resulting in a larger calculated value of dissolved oxygen[√].

(iii) 
$$2NO_2^{-1}\% I_2\% 2S_2O_3^{2-1}$$

Amount of  $S_2O_3^{2-}$  reacted with  $I_2$  formed from dissolved oxygen

= 
$$3.840 \times 10^{-5} - 5.70 \times 10^{-6}$$
  
=  $3.270 \times 10^{-5}$  mol

4S<sub>2</sub>O<sub>3</sub><sup>2-</sup> % O<sub>2</sub>

Amount of oxygen  $=\frac{1}{4} \times 3.270 \times 10^{-5}$ 

- (iv) DOC =  $8.18 \times 10^{-6} \times \frac{1000}{30} \times 32.0 \times 1000$ = 8.72 mg dm<sup>-3</sup>
- (v) There is enough oxygen to support small aquatic animals but not the larger fishes.

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## RVHS Chemistry

(c) (i)

	Mn	0
Mass %	72.0	100 - 72.0 = 28.0
Mole ratio	$\frac{72.0}{54.9} = 1.311$	$\frac{28.0}{16.0} = 1.75$
Adjusted Mole ratio	1	1.335
Simplest ratio	3	4

Empirical formula: Mn<sub>3</sub>O<sub>4</sub>

(ii) Average oxidation state = +(8/3) = +2.667+3 oxidation state: Mn<sub>2</sub>O<sub>3</sub>

The other oxide can only have oxidation state of either +2 or +1

Assuming +2 oxidation state: MnO and letting the proportion of  $Mn_2O_3$  be x:

(x)(3) + (1-x)(2) = 2.667

x = 0.667

Mn<sub>2</sub>O<sub>3</sub> : MnO ratio of 2:1

#### OR

Assuming +1 oxidation state:  $Mn_2O$  and letting the proportion of  $Mn_2O_3$  be x:

(x)(3) + (1-x)(1) = 2.667

x = 0.833

Mn<sub>2</sub>O<sub>3</sub> : Mn<sub>2</sub>O ratio of 5:1

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### **7 (a) (i)** $1s^2 2s^2 2p^6 3s^2 3p^6 3d^8 4s^2$

(ii) For all atoms, there is an <u>increase in successive ionisation energies</u> as the <u>electron is removed from an ion of increasing positive charge</u>.

The significant jump from the  $2^{nd}$  to the  $3^{rd}$  ionisation energy for element **A** and **B** is due the <u>removal of the  $3^{rd}$  electron from an inner principal</u> <u>quantum shell</u> which is more strongly attracted to the positive nucleus.

(iii) Element **B** is Mg.

(Both element **A** and **B** are from Group 2. Ionisation energies decrease down the group.)

(b) 
$$A_r \text{ of nickel} = (57.98 \times \frac{18.1}{18.1 + 44.9}) + (59.02 \times \frac{44.9}{18.1 + 44.9})$$
 [1]  
= 58.72 [1]

- (c) (i) From fluorine to iodine, the <u>number of electrons increases</u>, hence <u>more energy</u> is required to overcome the <u>stronger instantaneous dipole-induced dipole interactions between the halogen molecules</u>. This results in an increase in boiling point and a <u>decrease in volatility</u>.
  - (ii) The thermal stability of hydrogen halides <u>decreases down the group</u> due to decreasing H#X bond energy.

As the <u>size of halogen atoms increases</u>, their valence orbitals become more diffuse. This results in <u>less effective overlap of orbitals between</u> <u>the H atom and the halogen atom</u>. Thus, <u>less energy is required to</u> <u>break the weaker H#X bond</u>.

Table 7.2			
	X	Y	Z
nucleon number	121	86	35
charge	+1	+1	0

(d) (i)

10

[2]

[2]

[1]

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[1]



 Both X and Y are <u>deflected to the negative plate</u>, but Z is <u>not deflected</u>. This is because X and Y are <u>positively charged</u>, whereas Z is <u>electrically neutral</u>.

Since the mass of **X** is <u>higher</u> than that of **Y**, the angle of deflection of **X** will be <u>smaller</u> than that of **Y**.

(e) (i) 
$$K_{c} = \frac{[Br_{2}][Cl_{2}]}{[BrCl]^{2}}$$

initial amount of BrC*l* =  $\frac{13.9}{115.4}$  = 0.1205 mol

initial [BrC/] = 
$$\frac{0.1205}{2.00}$$
 = 0.06025 mol dm<sup>-3</sup>

change in [BrC/] =  $0.06025 \times 0.460 = 0.02772$  mol dm<sup>-3</sup>

	2BrC <i>l</i> (g)	= Br <sub>2</sub> (g) +	Cl <sub>2</sub> (g)
[ ]initial	0.06025	0	0
[ ]change	-0.02772	+1⁄2(0.02772)	+1⁄2(0.02772)
[ ]equilibrium	0.03253	0.01386	0.01386

$$K_{\rm c} = \frac{[{\rm Br}_2][{\rm C}l_2]}{[{\rm Br}{\rm C}l]^2} = \frac{(0.01386)^2}{(0.03253)^2} = 0.182$$

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[2]



(f) (i) The forward reaction is <u>exothermic</u>.

As <u>temperature decreases</u>, the <u>yield increases</u> This shows that a <u>low</u> <u>temperature favours the forward exothermic reaction to release some</u> <u>heat</u>, causing the <u>position of equilibrium to shift to the right</u>.

12

(ii)

The forward reaction involves an <u>increase</u> in the total number of gaseous molecules.

As <u>pressure decreases</u>, the yield increases. This shows that a <u>low</u> <u>pressure favours the forward reaction to increase the number of</u> <u>gaseous molecules</u>, causing the <u>position of equilibrium to shift to the</u> <u>right</u>.

8 (a) (i) HF is a weak Arrhenius acid because it partially dissociates in water to form H<sup>+</sup> (and F<sup>-</sup>).

 $H_2SO_4$  is a strong Arrhenius acid because it fully dissociates in water to form  $H^+$  and (SO<sub>4</sub><sup>2–</sup>).

- (ii)  $HF + H_2O = H_3O^+ + F^-$
- (iii) Acid: HF Conjugate base: F<sup>-</sup>
  Base: H<sub>2</sub>O Conjugate acid: H<sub>3</sub>O<sup>+</sup>
- (iii)  $K_a = \frac{[H_3O^+][F^-]}{[HF]} \mod dm^{-3}$

### RVHS Chemistry

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- **(b) (i)**  $K_w = [H^+][OH^-]$ 
  - (ii) Remains neutral.
    The concentration of H<sup>+</sup> and OH<sup>-</sup> are equal.
  - (iii)  $[H^+] = 2 \times [H_2SO_4] = 0.0500 \times 2 = 0.100 \text{ mol dm}^{-3}$ pH = -lg(0.100) = 1.00 (to 3 s.f)

(iv) 
$$[OH^{-}] = \frac{K_{w}}{[H^{+}]}$$

$$= \frac{1.00 \times 10^{-14}}{0.100}$$
$$= 1.00 \times 10^{-13} \text{ mol dm}^{-3}$$



(ii) Cis-trans isomerism arises due to the <u>restricted rotation about C=C bond</u> (and 2 different groups of atoms attached to same C of the C=C).

(iii) Br<sub>2</sub> in CCl<sub>4</sub>

Orange bromine decolourised

or

Br<sub>2</sub>(I)

Reddish-brown bromine decolourised





THE END

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